PROPORTIONAL VARIABLE RESISTOR STRUCTURES TO ELECTRICALLY MEASURE MASK MISALIGNMENT

This invention relates to the measurement of stitching offsets in etched interconnect layers, and more particularly, to structures, systems and methods employing proportional variable resistors suitable for electrically measuring unidirectional misalignment of stitched masks in etched interconnect layers.

One step in the production of a microdevice is photolithography in which contacts are patterned in a mask, on top of glass and the contacts are etched. After removal of the mask the patterned wafer is covered with a thin layer of aluminum. Applying lithography again, spaces between the aluminum lines are etched away, the mask is removed and a new layer is deposited. The glass layer is polished and the process is repeated until all layers of interconnect have been applied. The whole process hinges on the use of the photographic process to create the fine-featured patterns of the integrated circuit. A specific mask defines each layer of the chip and there are typically up to 24 mask layers in each IC.

As exposure areas have become increasingly large in keeping with the increased size of substrates, block exposure type stitching processes which partition the exposure area of the substrate into a plurality of unit areas (sometimes referred to as "shots" or "shot areas") and successively project and expose images of corresponding patterns on the shots have been developed. Such stitching of masks can result in misalignments which must be avoided since defects in masks can cause short circuits, open circuits or other design rule violations, any of which can be fatal to the functionality of the chip.

Therefore inspection and measurement of stitched masks is essential. Currently, the only known method of inspection is visual inspection employing devices such as scanning electron microscopes to detect misalignments. As fine geometries become smaller the ability to observe defects visually becomes more expensive and difficult.

Accordingly a need exists in the art for a method and/or device suitable for electrically measuring unidirectional misalignment of stitched masks in etched interconnect layers.

Figure 1 is a top plan view of masks according to the present invention.

Figure 2 is a top plan view of the masks of Figure 1 superimposed.

Figure 3 is a top plan view of the masks of Figure 1 superimposed and misaligned.

Figure 4 is a top plan view of the masks of Figure 1 superimposed and misaligned.

Figure 5 is a top plan view of masks according to a preferred embodiment of the present invention.

Figure 6 is a top plan view of the masks of Figure 5 superimposed.

Figure 7 is a top plan view of the masks of Figure 5 superimposed and misaligned.

Figure 8 is a top plan view of the masks of Figure 5 superimposed and misaligned.

Figure 9 is a top plan view of masks according to a most preferred embodiment of the present invention.

Figure 10 is a top plan view of the masks of Figure 9 superimposed.

Figure 11 is a top plan view of the masks of Figure 9 superimposed and misaligned.

Figure 12 is a top plan view of the masks of Figure 9 superimposed and misaligned.

In accordance with the invention, offset detection is isolated to one direction and mask misalignment is used as the variable resistor. In one embodiment the structure has a decreased resistance compared to that of its control structure when a positive offset on the secondary mask of a stitched mask set occurs. In another embodiment the structure has an increased resistance compared to that of its control structure when a positive offset on the secondary mask of a stitched mask set occurs.

Now referring to Figure 1 in a preferred embodiment a first reference mask 10 is provided comprising interconnect 12 and test pads 14 and 16. A second mask 20 is further provided, said second mask 20 comprising interconnect 22 and contact 24. In practice second mask 20 is superimposed on reference mask 10 to complete a resistor between test pads 14 and 16. Now referring to Figure 2 proper alignment of mask 10 and mask 20 produces the desired optimum structure shown in which interconnects 12 and 22 are vertically aligned. A resistance measurement is made by contacting test pads 14 and 16 with a suitable probe as known to those skilled in the art to establish the reference resistance of the optimum structure across contact 24. Now referring to Figure 3 if mask 20 is misaligned such that there is a smaller distance between interconnects 12 and 22 the resistance between the test pads 14 and 16 will decrease proportionally to the vertical offset. This is due to the fact that the resistance of an interconnect is proportional to the distance 24. Now referring to Figure 4, similarly, if the mask misalignment occurs such that there is a greater distance between interconnects 12 and 22, the resistance will increase proportionally. The geometry of the structure isolates the offset direction; i.e., horizontal offsets are not measured by what is shown in Figures 4 and 5.

Now referring to Figure 5 in another preferred embodiment a reference mask 30 is provided comprising "stick" type interconnects 32, 34, 36 and 38 and test pads 40, 42, 44 and 46. A second mask 50 is further provided, said second mask 50 comprising interconnect 52 and contact 54 and interconnect 56 and contact 58. In practice second mask 50 is superimposed on reference mask 30 to complete resistors between test pads 42 and 44 and between test pads 42 and 46. Now referring to Figure 6 proper alignment of mask 50 and mask 30 produces the desired optimum structure shown in which interconnects 34 and 52 are vertically aligned and interconnects 32 and 56 are vertically aligned. A resistance measurement is made by contacting test pads 42, 44 and 46 with a suitable probe as known to those skilled in the art to establish the reference resistance of the optimum structure across contacts 54 and 58.

Now referring to Figure 7 mask 50 of Figure 5 is misaligned in that it is oriented upward and to the right of its optimum location as seen in Figure 6. This mismatch results in a smaller distance between interconnects 32 and 56, therefore the resistance between the test pads 42 and 46 will decrease proportionally to the vertical offset. The mismatch also results in a larger distance between interconnects 34 and 52, therefore the resistance between pads 42 and 44 will increase proportionally. Now referring to Figure 8, if mask 50 is misaligned down and to the right of its optimum position there is a greater distance between interconnects 32 and 56, therefore the resistance will increase proportionally. In this example the distance between interconnects 34 and 52 is decreased; therefore the resistance will decrease proportionally.

Note that each direction is measured by one set of test pads, and the measurement directions are independent. Thus, horizontal misalignment is measured by interconnects 34, 36, 38 and 52 of Figure 7, while vertical misalignment is measured by interconnects 32 and 56.

Now referring to Figure 9 in a most preferred embodiment a first reference mask 60 is provided comprising "hook" type interconnect 62 and test pads 64 and 66. A second mask 70 is further provided, said second mask 70 comprising interconnect 72 and contact 74. In practice second mask 70 is superimposed on reference mask 60 to complete a resistor between test pads 64 and 66. Now referring to Figure 10 proper alignment of masks 60 and 70 produces the desired optimum structure shown in which interconnects 62 and 72 are vertically aligned. A resistance measurement is made by contacting test pads 64 and 66 with a suitable probe as known to those skilled in the art to establish the reference resistance

of the optimum structure across contact 74. Now referring to Figure 11 if mask 70 is misaligned, in this case, wherein the interconnects are aligned closer than they should be, there is an inversely proportional increase in resistance because there is a greater distance between interconnects 62 and 72 across contact 74. Now referring to Figure 12, similarly, if the masks are misaligned such that the interconnects 62 and 72 are moved further away from each other than optimum, there is a smaller distance between interconnects 62 and 72 across contact 74, therefore the resistance will decrease inversely to the direction in which the interconnects are misaligned.

In this manner mask mismatches may be measured simply by applying a probe to a test pad to measure the resistance between test pads. A method is thus provided for measuring stitched mask misalignment in etched interconnect layers by providing a reference mask having test pads disposed thereon and superimposing on said reference mask a second mask to provide proportional variable resistors between complementary test pads and interconnects of the respective masks, measuring the resistance of the proportional variable resistors, establishing an optimum resistance between interconnects, comparing the measured resistance to said optimum resistance and adjusting the position of said masks to alignment. When the resistance matches the reference resistance the masks are aligned.

While the above describes the preferred embodiment of the invention, various modifications or additions would be apparent to those of skill in the art. For example, the shapes of the interconnects are not limited to those set forth in the Figures. In addition the layout of the masks set forth herein are exemplary and the teachings of the present invention are applicable to any layout contemplated and not limited to what is shown in the Figures.